Citation for published version:
Sui, J & Rotsthein, P 2019, 'Self-prioritization and the attentional systems', *Current Opinion in Psychology*, vol. 29, pp. 148-152. https://doi.org/10.1016/j.copsyc.2019.02.010

DOI:
10.1016/j.copsyc.2019.02.010

Publication date:
2019

Document Version
Peer reviewed version

Link to publication

University of Bath

Self-prioritization and the attentional systems

Jie Sui[a] and Pia Rotshtein[b]

[a] Department of Psychology, University of Bath, Bath, UK

[b] School of Psychology, University of Birmingham, Birmingham, UK

Addresses for correspondence:

Jie Sui: J.Sui@bath.ac.uk

Department of Psychology

University of Bath

Claverton Down

Bath, BA2 7AY

United Kingdom

Abstract

Humans prioritize stimuli related to themselves rather than to other people. How we control these priorities is poorly understood, though it is relevant to the nature of self-processing and a wide range of neurological and neuropsychiatric disorders, from cases of strokes, dementia to depression and schizophrenia. We update the Self-Attention Network proposed in 2016 by evaluating how self-prioritization interacts with Peterson and Posner's three attentional systems: alerting, orienting and executive control, based on evidence on a variety of behavioural and neuroscientific studies with healthy participants and patients with brain lesions. We suggest that all the three attentional networks contribute to self-prioritization. Understanding the nature of self-prioritization in attentional contexts may provide important clinical implications for a variety of disorders related to self-processing.

Keywords: self-prioritization; alerting; orienting; executive control.

Introduction

Human attention is tuned by self-related information. Currently we know relatively little about which and how the attentional system(s) are tuned by self-related stimuli though the question is critical for understanding both the long-standing issue of what the nature of self-processing is and how human attention operates in social contexts. The aim of this paper is to elucidate the relations between self-processing and attentional functions. The review will provide evidence that self-related information act as a global modulator of attentional processing including orienting, arousal and executive control.

Ubiquitous phenomena: self-prioritization in cognition

There is now considerable evidence indicating that people prioritize information related to themselves relative to other people. The effects of self-prioritization are pervasive. For example, memory is better for information that relates to ourselves than others [1,2,3]. Self-related information attract attention automatically [4,5,6] and one's own face is responded to faster and more accurately than the faces of other people [7,8,9]. Self-prioritization even affects simple perceptual matching judgments [10,11]. In this task, people form associations between neutral stimuli (equally familiar) and personal significant labels (e.g. you, friend and stranger). Matching performances are better for self-associations than for the associations related to other people.

The most important account of self-prioritization is that the effects are driven by tuning attention toward self-related information [4]. In 2016, Humphreys and Sui proposed the Self-Attention Network (SAN) to help understand the nature of self-prioritization in attentional contexts. The review focused on the evidence of the self-name, self-face, and self-perception effects on attention. The authors argued that self-prioritization emerges through an interaction between regions within the self-network (the cortical midline structure, specifically the ventral medial prefrontal cortex, vmPFC) and regions within the executive control network [12]. The impact of executive functions on self-related processing, has also been noted in developmental research, where executive functions are associated with the development of self-control [13]. Going beyond this, the present article extends the SAN by evaluating and discussing the relationships between self-processing and the entire attentional system proposed by Petersen and Posner [14, 15]. This discussion unifies cognitive, neuroimaging and neuropsychological research findings on the interactions between self-processing and the attentional systems.

Peterson and Posner's three attentional system

An influential theory of attention postulates that attention is composed of three distinct neuro-cognitive networks: alerting, orienting and executive control [14, 15]. The alerting network controls participant's arousal and vigilance, and supports sustaining of attention over time. It is controlled by the norepinephrine (NE) circuit, originating in the brain stem and spreading across the cerebrum. The alerting network is associated with rapid phasic changes of vigilance (e.g. in response to a stimulus onset) or tonic state (e.g. as a function of the sleep-wake cycle). The orienting network prioritizes sensory input by enhancing processing resources to specific location, modality or object. It is controlled by the acetylcholine circuit. The orientating network is divided into two functions. Orientation to a target based on prior knowledge (e.g. spatial cue) is mediated via a lateral dorsal fronto-parietal network including the frontal eye field and intra-parietal sulcus (IPS). The second orienting sub-system is mediated via the ventral fronto-parietal network including the inferior frontal region and temporal-parietal junction. The latter is driven by the stimulus. It is typically measured by the ability to switch prioritization, re-orienting to a new target location. Finally, the executive control network reflects a top down regulation mechanism that creates the task set, ensures task goals being maintained, and monitors for conflict and error. It is mediated through at least two neural circuits: a lateral fronto-parietal and a medial frontal- insula.

How these attentional networks interact with the critical processes that affect our everyday lives and that are more social in nature is unclear. Research so far focused on the interaction between the attentional networks and emotions [16,17,18,19]. For example, using the attentional network test, Fan and colleagues (2002) reported interaction between emotions and the executive control network [20]. Humphreys and Sui suggested that personal significance affects behaviour through the interaction with the self-network (especially in the vmPFC) and the executive control system [12]. Here we extend the SAN by systematically evaluating the evidence of how social processing, with a focus on self-relevance, interacts with the entire attentional systems (**Figure 1**). We argue that self-processing acts as a modulator of the alertness and orienting systems, while it runs counter to the function of the executive control when the self-related information is irrelevant to task requirements and individual goals.

Self and Petersen and Posner's attentional networks

Self and alerting

Naturally self-relevant information tends to increase one's alertness. For example, hearing one's own name compared to the names of other people leads to increase autonomic responses (galvanic skin response), when participants are awake or during rapid-eye-movement (REM) stage of sleep [21]. Recently Kaida and Abe (2018) showed that self-name enhanced performance maintenance indexed by the psychomotor vigilance test (PVT). In the PVT test, repetitive simple task is performed over a relative long duration typically leading to boredom and decrease in performance [22]. Additional evidence comes from neurophysiological studies where the amplitude of P3 ERP (Event Related Potential) component is increased for self-name stimuli compared to other names in awake adults [23,24] and in individuals who are in vegetative state [25]. It has been suggested that physiologically the P3 is coupled with the responses of the autonomic nervous system, reflecting the activation of the locus coeruleus-norepinephrine system [26].

The evidence indicates that self-related stimuli, especially one's own name modulates alertness. It is noteworthy that these studies confound familiarity with the self-manipulation as participants are more familiar with their own name in relation to the names of other people. Future research needs to assess the effects of self-processing on alertness by controlling for stimulus familiarity.

Self and orienting

Orienting of attention is supported by two sub-systems: one is guided by top-down prior knowledge, and the other by new bottom up information. In other words orienting is guided by endogenous and exogenous cues, respectively.

There is a body of evidence indicating that self-related information is an effective endogenous cue that facilitates responses to targets, compared to information related to other people. Liu and colleagues (2016) used face images (self vs. other faces) as a central cue prior to the presence of a peripheral target (a letter 'T' surrounded by distractors '+'). The orientation of face images cued the location of the targets [27]. The authors found that the self-face cue (relative to other face) enhanced cue validity and facilitated responses to targets. The effect was associated with enhanced N1 amplitude in the parietal regions to the self-face cue. N1 amplitude in cueing tasks is suggested to reflect orienting of attention to target location [28]. Similarly, an avatar associated with the self can act as an affective cue to facilitate performance to targets in comparison to an avatar associated with a different person [29,30]. This suggests that self-relevant priori knowledge enhances orienting of attention.

Self-related stimulus is also a powerful exogenous cue, inherently capturing attention. The cocktail party effect is the most commonly used example. In a classic study, Moray (1959) reported that participants were able to recall more words in their unattended ear when they followed the presentation of participants' own name in comparison to the names of other people [4]. The result indicates that self-related stimuli orient attention to their location and subsequently facilitate the processing of stimuli in the same location. It is also shown that relative to other names self-name is detected faster in a search task [31] and captures attention when presented briefly in the location of following target [32]. Similar effects have been reported in face studies [7,33]. Using ERP, researchers reported that the amplitude of the anterior N2 component over the central frontal regions was larger for self faces (relative to the faces of friends), no matter whether the stimuli were task-relevant or not [34]. The anterior N2 is associated with orienting of attention, though it has also been suggested to contribute to executive control [35,36].

In addition, even when self-related stimuli are newly learned, they capture attention. Sui and colleagues (2015) had participants associate neutral geometric shapes with different people (self-triangle, friend-square, stranger-circle) [37,38]. Participants then were presented with compound shapes (e.g., global-square made of local-triangles) and asked to complete a global-local task [39,40], identifying the shapes at a given level (global vs. local). The data showed faster responses when the self-associated shape was the target compared to when it was presented as the distracter. The effect holds at both the global and local levels, and the response in the IPS mirrored the behavioural pattern. The researchers argued that the geometrical shape tagged to the self becomes salient, exhibiting similar effects on behaviour as a perceptual salient stimulus [40].

In line with the above effects, a recent neuropsychological study reported that self-related information helps reduce spatial attention deficits in extinction patients [41]. Extinction is a neuropsychological deficit in which patients can identify a single stimulus presented in the contralesional field but fail to notice it when a second item appears at the same time in the ipsilesional field. In this study, extinction patients first completed the shape-personal label matching task and then had to report the shapes presented on the screen. When two shapes were placed in competition, extinction patients more often reported their own shape than the shape associated with other people. The effect was larger when the self-related shape fell on the contra-lesional than ipisilesional side [41]. These results indicate that self-related stimuli increase attentional resources to the controlesional hemifield, which is typically ignored by extinction patients.

The neural responses involved in the shape-label matching task was examined using functional magnetic resonance imaging (fMRI) [42]. The researchers reported that the self-processing (in relation to other processing) was associated with enhanced activity in the ventral prefrontal cortex (vmPFC) and left posterior superior temporal sulcus (pSTS). In particular, the strength of the projections from the vmPFC onto the left pSTS correlated with the magnitude of self-prioritization in the shape-label matching task [42]. They argued that personal significance affects performance, by coupling activation in regions associated with internal self-representations in the vmPFC to brain regions associated with bottom-up based ventral orienting processes (the pSTS).

Taken together, the evidence shows that self-related stimuli act as ‘powerful’ orienting cues (endogenous or exogenous), modulating neural responses via the ventral orienting system to affect behavior. This is consistent with the idea that stimuli become salient based on not only their perceptual features but also social attributes of stimuli [15].

Self and executive control

We have evaluated the evidence that self-relevance modulates alerting and orienting of attention. Below we discuss the interaction between self-processing and executive control within the frontal cortex. The evidence suggests that the midline frontal structures drive self-prioritization, while the lateral frontal regions counter this pre-potent tendency to ensure task goals met.

It is worth noting that the ventral midline frontal structures (mFC) supporting self processes are hypothesised to be dissociated from the midline structures that are directly involved in executive control. A recent meta-analysis suggests partial functional dissociations along posterior-anterior axes of the medial frontal cortex; with the middle parts associated with cognitive control processes ('cold' cognition) and more anterior parts associated with 'warm' cognition, including social, affect and reward [43]. Though the meta-analysis also stressed high degree of overlaps in functions between the midline frontal structures, it highlights that the anatomical proximity potentially enables interactions among different processes [44]. For example, self-processing is typically associated with the ventral-posterior parts of the mFC, which dissociate from reward processing [45,46]. This is supported by the shape-label matching study described above [42], in which the vmPFC responses stronger to self-related stimuli than the stimuli associated with others; in contrast, the dorsal lateral prefrontal cortex (DLPFC) was associated with other-related processing. The strength of the DLPFC response in other- vs. self-trials inversely correlated with the size of self-prioritization observed in behavior [42].

The inverse role of the frontal midline and dorsal lateral structures in self-prioritization is also shown in two neuropsychological studies. A voxel-based morphometry study reported that lesions to the dorsal frontal areas were associated with hyper self-prioritization effect in face perception [47]. The size of self-prioritization was almost 2-3 folds larger in patients than in age matched healthy participants and patients with lesions not affecting this region. Furthermore, the exaggerated self-prioritization in these patients was associated with reduced performance in executive control tasks. This observation was replicated by another neuropsychological case study, where the shape-personal label matching task was used [48]. A patient with brain lesion affecting the lateral frontal and parietal regions showed abnormally increased self-prioritization observed in both perception and memory tasks tasks. In contrast, a patient with brain lesion affecting the frontal midline structures showed reverse pattern of hypo self-prioritization effects [48].

What is intriguing in the above findings is that none of the experimental conditions presents a direct competition between self and other related stimuli, in other words, experimental trials only contain targets without distracters. These results indicate that the role of the DLPFC is to counter self-prioritization even in the absence of direct competition from self-related stimuli. The findings indicate that the ventral frontal structures and dorsal lateral regions play an opposite role in self-prioritized responses.

Discussion and conclusions

There has been considerable debate over how self-related information gains and operationalises attentional priority. One interpretation is that self-related information gains priority through motivational/affective neural circuits associated with reward and emotions [46,49]. There is some evidence suggesting that self-related information at least partly guides behaviour via unique mechanisms differing from reward and emotion systems [50,51,52]. This is, however, beyond the scope of the current review to compare the differential effects of self from other 'warm' (motivational and affective) stimuli on the attention systems in detail.

Another account is that self-reference (referring a stimulus to the self) activates internal self-representations which modulate the links between sensory input to different levels of processing from perception, attention to memory [53], and somehow self-reference acts as a gold thread to facilitate processing of information (like 'a centre of the gravity') [54]. Following this line of research, the present article particularly focuses on the effects of self-prioritization in attentional contexts. We update the SAN model by systematically evaluating and discussing the relationships between self-processing and the three attentional networks proposed by Petersen and Posner: alerting, orienting, and executive control. The evidence suggests that self-reference modulates all the components of the attentional system: self-related stimuli increase alertness, act as efficient endogenous and exogenous cues; the interaction between self-processing and executive control depends on task demands which either contribute to self-prioritization or supress the self-prioritization when self-related stimuli are task-irrelevant.

We conclude that in order to survive in complex environments people need to prioritize processing so that stimuli most relevant to our behavioral goals are selected for action, self-processing acts a global modulator of the attentional systems, by interacting with all the three networks. We hope the present review will be useful as a theoretical framework for future studies on self and attention, with direct implications for different neurological and neuropsychiatric disorders related to self-processing.

Acknowledgements

This work was supported by the Alzheimer's Research UK to J.S.

References and recommended reading

1. Symons C, Johnson B: **The self-reference effect in memory: A meta-analysis**. *Psychol Bull* 1997, **121**:371-394.

2. Conway MA, Pleydell-Pearce CW: **The construction of autobiographical memories in the self memory system**. *Psychol Rev* 2000, **107**:261–288.

3. Cunningham SJ. Turk DJ, Macdonald LM, Neil Macrae C: **Yours or mine? Ownership and memory**. Conscious *Cogn* 2008, **17**:312–318.

4. Moray N: **Attention in dichotic listening: Affective cues and the influence of instructions**. *Q J Exp Psychol* 1959, **11**:56–60.

5. Turk DJ, van Bussel K, Brebner JL, Toma AS, Krigolson O, Handy TC: **When "it" becomes "mine": attentional biases triggered by object ownership**. *J Cogn Neurosci 2011,* **23***:*3725-3733.

6. Brédart S, Delchambre M, Laureys S: **One's own face is hard to ignore**. *The Q J Exp Psychol* 2006, **59**:46–52.

7. Tong F, Nakayama K: **Robust representations for faces: evidence from visual search**. *J Exp Psychol Hum Percept Perform* 1999, **25**:1016–1035.

8. Sui J, Han S: **Self-construal priming modulates neural substrates of self-awareness**. *Psychol Sci 2007,* **18***:*861-866.

9. Keyes H, Brady N, Reilly RB, Foxe JJ: **My face or yours? Event-related potential correlates of self-face processing**. *Brain Cogn* 2010, **72**:244–254.

10. Sui J, Liu CH, Wang L, Han S: **Attentional orientation induced by temporarily established self-referential cues**. *Q J Exp Psychol 2009,* **62**:844-849.

11. Sui J, He X, Humphreys GW: **Perceptual effects of social salience: Evidence from self-prioritization effects on perceptual matching**. *J Exp Psychol Hum Percept Perform 2012,* **38**:1105-1117.

12. •• Humphreys GW, Sui J: **Attentional control and the self: The Self-Attention Network (SAN)**. *Cogn Neurosci 2016,* **7**:5-17.

13. Posner MI, Petersen SE: **The attention system of the human brain**. *Annu Rev Neurosci* 1990, **13**:25–42.

14. Posner MI, Rothbart MK, Voelker P: **Developing brain networks of attention**. *Curr Opin Pediatr* 2016, **28**:720-724.

15. •• Petersen SE, Posner MI: **The attention system of the human brain: 20 years after**. *Annu Rev Neurosci* 2012, **35**:73-89.

16. Birk JL, Dennis TA, Shin LM, Urry HL: **Threat Facilitates Subsequent Executive Control During Anxious Mood**. *Emotion* 2011, **11**:1291–1304.

17. Cohen N, Henik A, Mor N: **Can emotion modulate attention? Evidence for reciprocal links in the Attentional Network Test**. *Exp Psychol* 2011, **58**:171–179.

18. Dennis TA, Chen CC, McCandliss BD: **Threat-related attentional biases: An analysis of three attention systems**. *Depress Anxiety* 2008, **25**:E1. doi:10.1002/da.20308.

19. Vuilleumier P, Huang YM: **Emotional attention: Uncovering the mechanisms of affective biases in perception**. *Curr Dir Psychol Sci* 2009, **18**:148-152.

20. Fan J, McCandliss BD, Sommer T, Raz A, Posner MI: **Testing the efficiency and independence of attentional networks**. *J Cogn Neurosci* 2002, **14**:340-347.

21. •Feld GB, Specht M: **Differential electrodermal and phasic heart rate responses to personally relevant information: Comparing sleep and wakefulness**. *Sleep Biol Rhythms* 2010, **8**:72-78.

22. Kaida K, Abe T: **Attentional lapses are reduced by repeated stimuli having own-name during a monotonous task**. *PLoS ONE* 2018, **13**:e0194065.

23. Berlad I, Pratt H: **P300 in response to the subject's own name.** *Electroencephalogr Clin Neurophysiol* 1995, **96**:472-474.

24. •Fan W, Chen J, Wang X, Cai R, Tan Q, Chen Y, *et al.*: **Electrophysiological correlation of the degree of self-reference effect**. *PLoS ONE* 2013, **8**:e80289.

25. Perrin F, Schnakers C, Schabus M, Degueldre C, Goldman S, Bre´dart S, *et al.*: **Brain Response to One's Own Name in Vegetative State, Minimally Conscious State, and Locked-in Syndrome**. *Arch Neurol* 2006, **63**:562-569.

26. Nieuwenhuis S, De Geus EJ, Aston-Jones G: **The anatomical and functional relationship between the P3 and autonomic components of the orienting response**. *Psychophysiology* 2011, **48**:162-175.

27. Liu M, He X, Rotshtein P, Sui J: **Dynamically orienting your own face facilitates the automatic attraction of attention**. *Cogn Neurosci* 2016, **7**:37-44.

28. Luck SJ, Hillyard SA, Mouloua M, Woldorff MG, Clark VP, Hawkins HL: **Effects of spatial cuing on luminance detectability: Psychophysical and electrophysiological evidence for early selection**. *J Exp Psychol Hum Percept Perform* 1994, **20**:887-904.

29. Mattan B, Quinn KA, Apperly IA, Sui J, Rotshtein P: **Is it always me first? Effects of self-tagging on third-person perspective-taking**. *J Exp Psychol Learn Mem Cogn* 2015, **41**:1100-1117.

30. Sun Y, Fuentes LJ, Humphreys GW, Sui J: **Try to see it my way: Embodied perspective enhances self and friend-biases in perceptual matching**. *Cognition* 2016, **153**:108-117.

31. Yang HS, Wang F, Gu NJ, Zhang Y: **Self-advantage in the online world**. *PLOS ONE* 2015, **10**:e0140654.

32. Alexopoulos T, Muller D, Ric F, Marendaz C: **I, me, mine: Automatic attentional capture by self-related stimuli**. *Eur J Soc Psychol* 2012, **42**:770-779.

33. Wójcik MJ, Nowicka MM, Kotlewska I, Nowicka A: **Self-face Captures, Holds, and Biases Attention**. *Front Psychol* 2018, **8**:2371.

34. Sui J, Zhu Y, Han S: **Self-face recognition in attended and unattended conditions: an event-related brain potential study**. *Neuroreport* 2006, **17**:423-427.

35. Näätänen RA, Gaillard WK: **The Orienting Reflex and the N2 Deflection of the Event-Related Potential (ERP)**. *Adv Psychol* 1983, **10**:119-141.

36. Folstein JR, Van Pettena C: **Influence of cognitive control and mismatch on the N2 component of the ERP: A review**. *Psychophysiology* 2008, **45**:152–170.

37. •Sui J, Liu M, Mevorach C, Humphreys GW: **The salient self: The left intra-parietal sulcus responds to social as well as perceptual-salience after self-association**. *Cereb Cortex 2015*, **25**:1060-1068.

38. Liu M, Sui J: **The interaction between social saliency and perceptual saliency**. *Q J Exp Psychol 2016,* **28**:1-33.

39. Navon D: **Forest before trees - precedence of global features in visual-perception**. *Cogn Psychol* 1977, **9**:353-383.

40. Mevorach C, Hodsoll J, Allen H, Shalev L, Humphreys GW: **Ignoring the elephant in the room: a neural circuit to downregulate salience**. *J Neurosci* 2010, **30**:6072-6079.

41. •Sui J, Humphreys GW: **The self survives extinction: Self-association biases attention in patients with visual extinction**. *Cortex 2017*, **95**:248-256.

42. •Sui J, Rotshtein P, Humphreys GW: **Coupling social attention to the self forms a network for personal significance**. *Proc Natl Acad Sci* U S A *2013,* **110***:*7607-7612.

43. De la Vega A, Chang LJ, Banich MT, Wager TD, Yarkoni T: **Large-scale meta-analysis of human medial frontal cortex reveals tripartite functional organization**. *J Neurosci* **36**:6553–6562.

44. ••Sui J, Gu X: **Self as Object: Emerging Trends in Self Research**. *Trends Neurosci* 2017, **40**:643-653.

45. Northoff G, Bermpohl F**: Cortical midline structures and the self**. *Trends Cogn Sci* 2004, **8**:102-107.

46. Yankouskaya A, Humphreys GW, Mortiz S, Stroke M, Sui J: **An anterior-posterior axis within the ventromedial prefrontal cortex separates self and reward**. *Soc Cogn Affect Neurosci* 2017, **12**:1859-1868.

47. • Sui J, Chechlacz M, Rotshtein P, Humphreys GW: **Lesion-symptom mapping of self-prioritization in explicit face categorization: Distinguishing hypo- and hyper-self bias**. *Cereb Cortex* 2015, **25**:374-383.

48. Sui J, Enock F, Ralph J, Humphreys GW: **Dissociating hyper- and hypo-self biases to a core self-representation**. *Cortex* 2015, **70***:*202-212.

49. Northoff G, Hayes DJ: **Is our self nothing but reward**? *Biol Psychiatry* 2011, **69**:1019–1025.

50. Ma Y, Han S: **Why respond faster to the self than others? An implicit positive association theory of self advantage during implicit face recognition**. *J Exp Psychol Hum Percept Perform* 2010, **36**:619–633.

51. Sui J, Yankouskaya A, Humphreys GW: **Super-capacity and violations of race independence for self- but not for reward-associated stimuli**. *J Exp Psychol Hum Percept Perform* 2015, **41**:441-452.

52. Stolte M, Humphreys GW, Yankouskaya A, Sui J: **Dissociating biases towards the self and positive emotion**. *Q J Exp Psychol* 2017, **70**:1011-1022.

53. ••Sui J, Humphreys GW: **The integrative self: How self-reference integrates perception and memory**. *Trends Cogn Sci 2015,* **19**:719-728.

54. Sui J: **Self-reference acts as a golden thread in binding**. *Trends Cogn Sci* 2016, **20**:482-483.

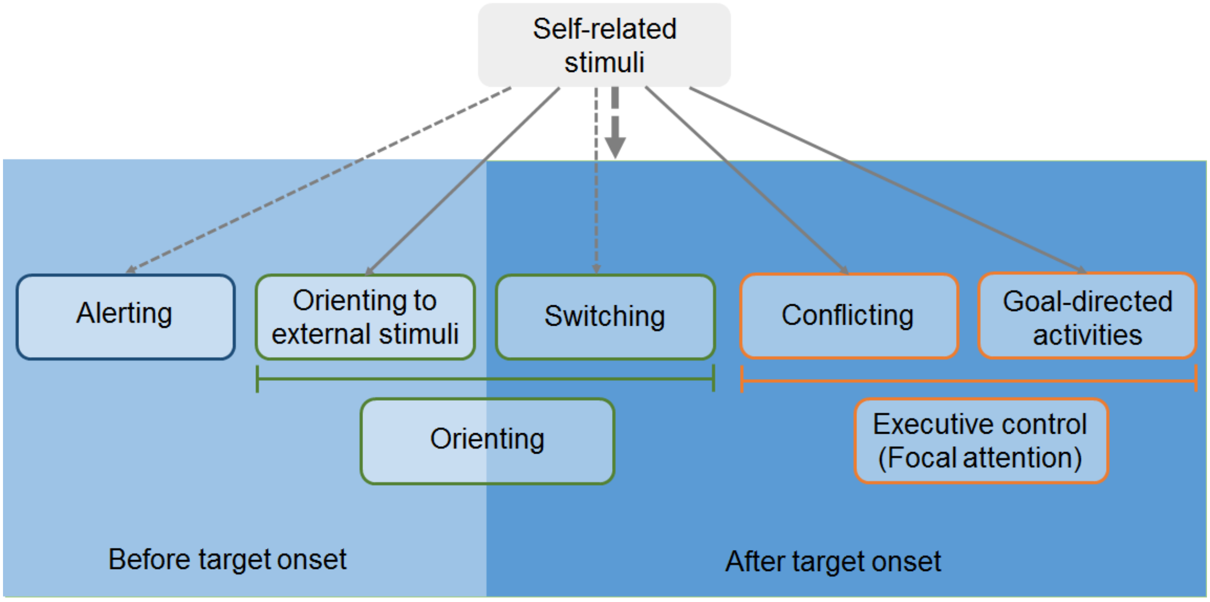

Figure 1 Self-Attention Interaction Framework